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NATIONAL DAM SAFETY PROGRAM. HIGHLAND LAKE DAM (NJ00033), HUDSO--ETC(U)
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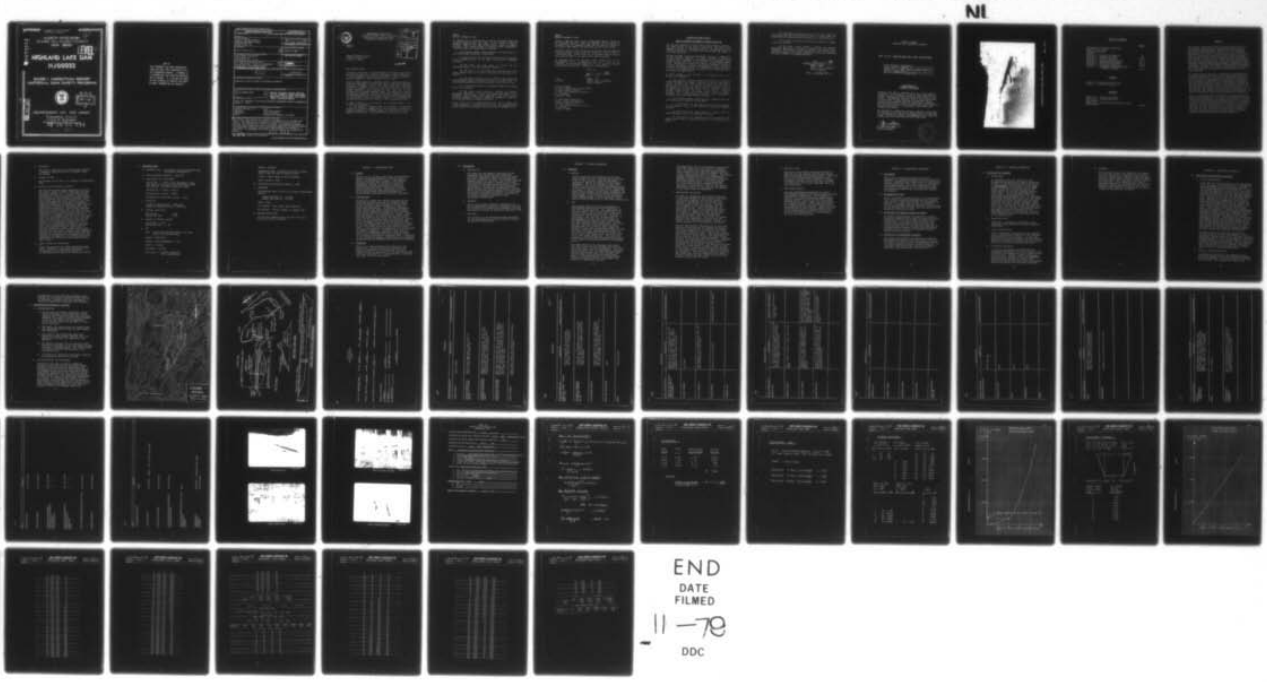

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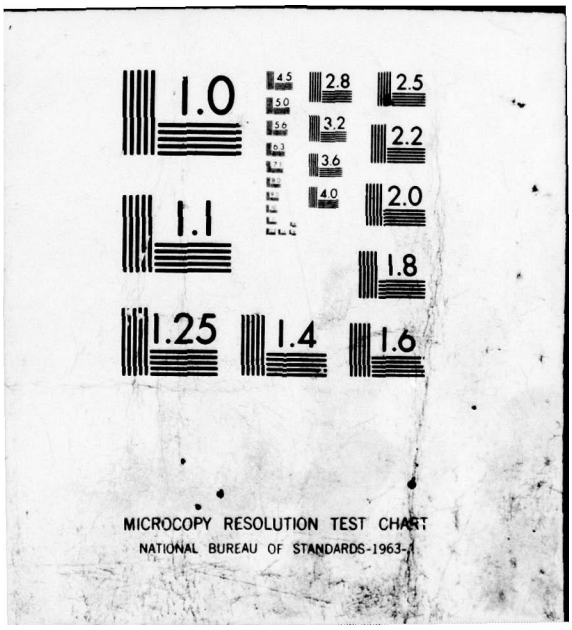
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HUDSON RIVER BASIN
DOUBLE KILL, SUSSEX COUNTY
NEW JERSEY

LEVEL II

HIGHLAND LAKE DAM

NJ00033

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

August 1979

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
NJ00033		

4. TITLE (and Subtitle)
Phase I Inspection Report
National Dam Safety Program
Highland Lake Dam
Sussex County, N.J.

5. TYPE OF REPORT & PERIOD COVERED
(9) FINAL Sept 15

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Jolls, F.Keith, P.E.

8. CONTRACT OR GRANT NUMBER(s)
(15) DACW61-79-C-0011

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Louis Berger & Associates
100 Halstead Ave.
East Orange, N.J. 07019

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
(11) U.S. Army Engineer District, Philadelphia
Custom House, 2d & Chestnut Streets
Philadelphia, Pennsylvania 19106

12. REPORT DATE
Aug [redacted] 79

13. NUMBER OF PAGES
35

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
(12) 61

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

(10) F. Keith /Jolls

(6) National Dam Safety Program. Highland Lake Dam (NJ00033), Hudson River Basin, Double Kill, Sussex County, New Jersey. Phase I Inspection Report.

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia, 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Highland Lake Dam, N.J.	Dams
Spillways	Structural Analysis
Embankments	Visual Inspection
Weirs	National Dam Inspection Act Report

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, NJ 08621

25 SEP 1979

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Highland Lake Dam in Sussex County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Highland Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 46 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure.

To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure

the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system, should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. The following remedial actions should be completed within one year from the date of approval of this report:

(1) The cracks in the ogee weirs should be filled with epoxy and the expansion joints at the corners of spillway #2 wingwalls recaulked.

(2) The debris and trash should be cleared from the downstream channels and the main embankment backslope.

(3) The zones on the downstream slope with excessively steep grades (greater than 1:1) should be flattened with additional rock backfill.

(4) The manhole entrance for the blow-off valve should be uncovered and the top casting raised and reset to roadway grade. The valve should be rehabilitated and the entrance inlet cleared of silt.

(5) A V-notch weir should be installed to monitor the seepage at the toe of the dam.

(6) The owners should develop a checklist for periodic maintenance inspections so a record of conditions and repairs can be maintained. Key personnel of their maintenance staff should be given additional training in dam safety inspection procedures so that they can correctly monitor the seepage conditions.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this

letter, a copy will also be sent to Congressman James A. Courter of the Thirteenth District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

1 Incl
As stated

Copies furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Management
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

HIGHLAND LAKE DAM (NJ00033)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 16 May 1979 by Louis Berger & Associates, Inc. under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Highland Lake Dam, a high hazard potential structure, is judged to be in fair overall condition. The dam's spillway is considered inadequate since 46 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure.

To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system, should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. The following remedial actions should be completed within one year from the date of approval of this report:

(1) The cracks in the ogee weirs should be filled with epoxy and the expansion joints at the corners of spillway #2 wingwalls recaulked.

(2) The debris and trash should be cleared from the downstream channels and the main embankment backslope.

(3) The zones on the downstream slope with excessively steep grades (greater than 1:1) should be flattened with additional rock backfill.

(4) The manhole entrance for the blow-off valve should be uncovered and the top casting raised and reset to roadway grade. The valve should be rehabilitated and the entrance inlet cleared of silt.

(5) A V-notch weir should be installed to monitor the seepage at the toe of the dam.

(6) The owners should develop a checklist for periodic maintenance inspections so a record of conditions and repairs can be maintained. Key personnel of their maintenance staff should be given additional training in dam safety inspection procedures so that they can correctly monitor the seepage conditions.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 25 Sep 79

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam Highland Lake Dam Fed. ID# NJ 00033

State Located New Jersey
County Located Sussex
Coordinates Lat. 4110.8 - Long. 7427.6
Stream Double Kill
Date of Inspection 16 May 1979

ASSESSMENT OF GENERAL CONDITIONS

Highland Lake Dam is assessed to be in a fair overall condition. No detrimental findings were uncovered but further hydraulic studies should be undertaken in the future. Recommended remedial actions to be undertaken in the future include patching the concrete weirs, clearing and regrading the main embankment, exposing and raising the valve manhole casting to crest elevation and the development of a systematic monitoring and inspection program.

The dam has an inadequate spillway capacity, being able to accomodate only 45% of the design flood but the dam is not assessed an UNSAFE, NON-EMERGENCY as it does not comply with the provisions of ETL 1110-2-234.

F. Keith Jolls P.E.
Project Manager

OVERVIEW OF HIGHLAND LAKE DAM

MAY, 1979

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
NAME OF DAM: HIGHLAND LAKE DAM FED ID #NJ 00033
NJ ID # 258

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority

This report is authorized by the Dam Inspection Act, Public Law 92-367, and has been prepared in accordance with Contract FPM-36 between Louis Berger & Associates, Inc. and the State of New Jersey and its Department of Environmental Protection, Division of Water Resources. The State, in turn, is under agreement with the U.S. Army Corps of Engineers, Philadelphia to have this inspection performed.

b. Purpose of Inspection

The purpose of this inspection is to evaluate the structural and hydraulic condition of the Highland Lake Dam and appurtenant structures, and to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances

The dam at Highland Lake is an 850' long earth structure with a maximum height of 22 feet and has a steel sheet-piling cutoff to bedrock within the main 340 foot embankment area next to the right abutment. Two concrete spillways are located in the vicinity of the left abutment. Both extend down to bedrock and accommodate the normal flows from the man-made lake. The dam geometry is very irregular at the left end and contains a large rock outcropping within the lake area where a private residence is located. Lakeside Drive, a two lane village thoroughfare crosses the main embankment. An abandoned 24" low-level drain is located in the main embankment.

b. Location

Highland Lake Dam is situated at the northern end of Highland Lake on Double Kill, a tributary to Warwick, and subsequently, Wawayanda Creeks. The dam is located approximately 4 miles west of Upper Greenwood Lake in the community of Highland Lakes, Vernon Township, Sussex County.

c. Size Classification

The principal embankment of the dam has a maximum height of 22 feet and the reservoir has a maximum storage capacity of 3200 acre-feet. Accordingly, this dam is placed in the intermediate size category as defined by the criteria in the Recommended Guidelines for Safety Inspection of Dams (storage between 1,000 and 50,000 acre-feet).

d. Hazard Classification

The area immediately downstream of the dam consists of approximately 28 acres of undeveloped marshland which is crossed by two of the major streets within the village. Twelve hundred feet below the dam the discharge from Highland Lake passes through a 10' wide by 6' high corrugated steel arch pipe culvert which discharges into Lake Wanda. Within the flood plain, there is a fire house on the upstream side of the street and a small diner on the downstream side of the outlet. Additionally, there are numerous homes along the shoreline of Lake Wanda. Although it is anticipated that the marshland immediately downstream would absorb the initial impact of a dam break flood, it is possible that the downstream community could sustain appreciable damage and endanger the residents and traffic on the street system below the dam. Therefore it is recommended that this dam be classified in the high hazard category as failure could cause serious damage to the street system, utilities and residences surrounding Lake Wanda.

e. Ownership

This dam is owned by the Highland Lakes Country & Community Association Inc., Highland Lakes, New Jersey.

f. Purpose of Dam

The purpose of the dam is to impound a recreational lake.

g. Design and Construction History

The dam and spillways were designed in 1935 by the firm of Snook & Hardin, Engineers and Land Surveyors, Newton, N.J. At that time the new recreational facility was known as Lake Vernon. Construction of the dam began in August 1935 by the contracting firm of John Heller Inc. with final State approval being granted in July 1937. Sometime between that date and a subsequent inspection conducted in September, 1946, certain (apparently unauthorized) modifications were made to both spillways. The westerly spillway length was reduced from 140 to 12 feet by the construction of a private access road and bridge leading to a residence which was built on a large rock outcropping in front of the dam. Additionally, the channel below the other (60 foot wide) spillway near the middle of the dam was filled in to increase the usable land area adjacent to the peninsula residence. At that time, it was recommended by State inspectors that these modifications be removed but a further inspection in May, 1948 revealed that this had not been done. However, the inspecting engineer at that time felt the reduced spillway capacity was adequate and recommended that the alterations be approved. No further action was apparently ever taken and these modifications exist today.

h. Normal Operating Procedures

There are presently no formal operating procedures. However, a full-time maintenance crew is employed by the Lake Association for groundskeeping and repair of community property.

1.3 PERTINENT DATA

a. Drainage Area: 2.28 square miles of woodland and residential development.

b. Total spillway capacity - 1404 cfs.

c. Elevations (ft. above MSL)

Top of dam - 1194.0 (main embankment crest)
The crest in the area of the spillways varies considerably - average elevation 1,198±.

Spillway No. 1 crest - 1190.5

Spillway No. 2 crest - 1190.0

Streambed at centerline of dam - 1172±

d. Reservoir

Length of maximum pool - 8850 feet
Length of recreation pool - 8800 feet

e. Storage (acre-feet)

Top of dam	-	3,200
Recreation pool	-	1,850

f. Reservoir Surface (acres)

Top of dam	-	349
Recreation pool	-	325

g. Dam

Type - Earth with sheeted cutoff, low level drain, and two spillways

Length - 850± feet

Length of main embankment - 340'

Height - 22 feet

Top Width - 30 feet

Side slopes - 2.5H:1V (Upstream)
1H:1V (Downstream)

Zoning - Unknown

Impervious Core - Concrete core wall at both ends of dam (at ends of sheet piling)

Cutoff - Steel sheet piling to bedrock

Grout curtain - None

h. Diversion and Regulating Tunnel - None

i. Spillways

Two concrete weirs (with 6 to 1 batter downstream faces):

Length spillway #1 - 60 feet
Length spillway #2 - 12 feet

Gates - None

U/S Channel - None (main lake reservoir)

D/S Channel - Narrow channel in swampy area

j. Regulating Outlets

One 24 inch diameter cast iron blow-off pipe with gate valve in manhole.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Details of the original dam design were obtained from two drawings prepared in 1935 by Snook & Hardin, the designers of record. The drawings depicted sections and a profile of the main embankment, details of the sheet piling, the reinforced concrete spillways and low-level blow-off pipe and valve. While the original design calculations were unavailable, a review of the design plans indicates the dam was conservatively designed and correctly installed.

2.2 CONSTRUCTION

Construction inspection reports prepared by the assistant division engineer of the State Water Policy Commission were available from the files of the Division of Water Resources, Bureau of Flood Plain Management. In addition, correspondence between the design engineer and the State Water Policy Commission during the 1935 construction period were also available for review. These describe several minor revisions in design which were requested by the design engineer but do not appear on the available plans or inspection reports. It is indicated that the steel sheet piling was driven to bedrock along the entire 340 foot length of the main embankment with the exception of a short area to the right of the existing stream channel (where it was anchored to bedrock by a 20 foot length of concrete corewall). Suitable clayey fill was utilized as embankment upstream of the sheeting while a more sandy material and a boulder filter toe formed the downstream embankment zone. According to the inspection reports, construction was carefully supervised and "workmanship was excellent throughout".

2.3 OPERATION

There is no data available with respect to the operations. Details of the blow-off pipe and valve are depicted on the plans but the valve chamber access is paved over by the road on the dam crest and at present it is not possible to regulate the water level by this outlet.

2.4 EVALUATION

a. Availability

The stability and phreatic condition of the embankment and foundation were evaluated utilizing information obtained from the design drawings, inspection reports and engineering geology reports of the area. The latter indicate that Highland Lake Dam is located in an area underlain by Pre-Cambrian Losee gneiss, a white, metamorphic granitoid with a well-developed joint system. Overlying the bedrock is a thin mantle of glacial moraine and/or recent alluvium. As the dam is founded on bedrock it is felt that sufficent engineering information is available to provide a cogent evaluation of the engineered construction.

b. Adequacy

The original design drawings, inspection reports, and general geologic information available are sufficient to perform the assessment of this dam without recourse to gathering additional data.

c. Validity

The validity of the engineering data available is not challenged and accepted without recourse to further investigation.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General

Visual inspection of Highland Lake Dam took place on May 16, 1979. The dam was considered to be in fair overall condition although a substantial amount of remedial action appears necessary. Due to the irregular shape, the addition of the crest roadway and regraded areas in the center portion of the overall impounding structure, it was quite difficult to discern the exact limits between the man-made embankment and natural rock outcrops which formed several bedrock saddles in the vicinity of the spillways. These saddles appear to have impounded a much smaller natural lake prior to the 1935 construction.

b. Dam

The configuration of the main embankment is considerably modified from that indicated on the 1935 design drawings. The embankment, as orginally built, had a twelve foot wide crest, 2.5H:1V side slopes and four feet of design freeboard to the spillway crests. However, at the present time, the top of embankment is approximately 30 feet wide and is capped by the asphalt-paved Lakeside Drive which links the east and west shore communities. The crest has been widened by dumping large boulders, crushed rock, and gravel on both slopes and appears to have been accomplished without regard to slope stability. The downstream slope in most areas is approximately 1H:1V and the elevation of the undulating crest now varies from 4 to 6 feet above normal pool. The two lane pavement is severely deteriorated and has extensive cracking and numerous potholes and patched areas.

The upper zones of the upstream slope varies from 1H:1V near the left abutment to 2H:1V at the right end of the main embankment. The light brush and grass cover is separated by numerous erosion gullies near the right abutment where several small docks have been constructed. Several large boulders have also been placed along the upstream edge of the pavement and function as vehicular barriers.

The downstream slope is extensively covered with brush and trees (up to 20 inches in diameter) and is protected with numerous large boulders, (which appear to have been end-dumped) and contains a considerable amount of debris. Continuous seepage emanates from the right embankment/abutment juncture and flows northward along the downstream slope of toe. Additional seepage was noted approximately 75 feet downstream of the toe of the right embankment and 150 feet east of spillway #1. Most of the seepage contained a heavy iron precipitate and appears at the lower zones of embankment.

c. Appurtenant Structures

The dam, as originally constructed, contained a centrally located 24 inch blow-off pipe with a gate valve chamber, and the two concrete spillways located west of the natural rock outcrop in the middle of the dam. The gate valve chamber is now inaccessible since its top is paved over. Heavy siltation at the downstream toe has all but blocked the outlet pipe (only the upper six inches of the pipe is visible). Judging from the condition of the road pavement, the gate has not been operated for many years. The inlet is located about 60 feet upstream of the dam axis and appears to be completely buried. However, the outlet headwall is in satisfactory condition.

The two ogee crested spillways are in solid but weathered condition but the downstream channel capacity of spillway #1 is somewhat restricted by a stone masonry wall positioned 2 to 3 feet immediately below the crest. The discharge drops into a narrow channel about 4 foot deep where it flows laterally to the right and enters a short section of rectangular concrete channel. Spillway #2 (near the left abutment) is now topped by a timber bridge which provides access to the residence on the peninsula. The hydraulic headroom under the bridge soffit is about 2 feet but the 12 foot weir is positioned sufficiently upstream of the bridge fascia so that it does not restrict the discharge. The discharges from the two spillways merge just south of Lakeside Drive (which crosses the dam) and flow north thru two 48 inch diameter pipes under the road.

d. Reservoir Area

The terrain surrounding the lake consists of modestly sloping, wooded residential development on both the east and west slopes. The north end of the lakebed exhibits signs of heavy siltation but much of the shoreline is formed by bedrock outcrops and is very well defined. All homes are 8 to 10 feet (minimum) above dam crest elevation.

e. Downstream Channel

The area immediately downstream is a flat, undeveloped marshland with heavy stands of trees and secondary vegetation. The discharge is carried in a narrow meandering channel after passing through the twin 48 inch pipes under Lakeside Drive. Their invert is 7 feet below the roadway pavement. About 1000 feet north, the discharge flows into Lake Wanda through a corrugated steel arch culvert. There is a pump house located 30 feet from the channel about 50 feet downstream of Lakeside Drive but it could not be determined if it is connected in any way with the study dam.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no formal operating instructions presently in existence although the Lake Association employs a permanent maintenance crew in addition to seasonal part-time help. This staff is responsible for groundskeeping, preventive maintenance, lake operations, and repairs to the community property but present procedures are restricted by funding limitations.

4.2 MAINTENANCE OF DAM

While the primary responsibility of the maintanence staff centers around groundskeeping, their duties also extend to repair work within their capability. However, it appears that the dam is presently receiving less than adequate attention (as indicated by the accumulation of trash and thick growth on the embankment downstream slope).

4.3 DESCRIPTION OF WARNING SYSTEM IN EFFECT

No formal warning system is presently in effect. Observant residents living near the dam could note conditions during heavy storms and notify local authorities. It is again noted, however, that several downstream homes around Lake Wanda are situated quite close to the shoreline and only an automated warning system could provide sufficient advance notice in case of a hazardous flooding condition or dam failure.

4.4 EVALUATION OF OPERATIONAL ADEQUACY

The present operational procedures and community safeguards are deemed to be inadequate in view of the position of the dam and the downstream hazards. An overall community warning system should be developed along with a more intensive program of inspection and maintenance (see Section 7).

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data

In accordance with the criteria in the Recommended Guidelines for Safety Inspection of Dams, it has been determined that the dam is intermediate in size and is in the high hazard category. Accordingly, the spillway design flood (SDF) was determined by the Guidelines to be the full probable maximum flood (PMF). The inflow hydrograph was calculated using precipitation data from Hydrometeorological Report #33. In accordance with Corps of Engineers directives, the inflow hydrograph and flood routing were performed utilizing the HEC-1 computer program. Peak inflow to the reservoir for the full PMF was 10578 cfs. When routed through the reservoir, this reduced to 3104 cfs. The combined spillway capacity before overtopping of the embankment occurs is 1,404 cfs and is therefore inadequate and can accommodate only 45% of the design flood.

b. Experience Data

There was no information available to the inspection team concerning the past hydraulic performance.

c. Visual Observations

Visual inspection indicates that the hydraulic review substantially conforms to the drainage characteristics of this basin. It was also noted that the level driveway area each side of spillway #2 would also function as an auxiliary outlet in the case of extreme high water.

d. Overtopping Potential

In view of the hazard classification the overtopping potential is of some concern to the inspection team especially if ice should block the spillways. However, modest overtopping would do little damage to the main embankment except possibly to wash out some of the unprotected downstream slope areas and possibly scour out portions of the roadway shoulders.

e. Drawdown

At the present time it is impossible to dewater the lake via the 24" blowoff pipe as the gate valve is inaccessible. However, using this pipe, it would take at least 28 days to draw the lake down from normal pool elevation without inflow to the reservoir. Since dewatering the lake is presently impossible, accessibility to the valve chamber should be provided and the gate valve inspected and repaired, if necessary, to provide a means of draining the reservoir.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations

Based upon the field inspection, the dam appears to be in a fair overall condition. Although the main embankment's trapezoidal shape has been widened considerably by the addition of the road, the seepage observed is a stable but continuous problem and appears to occur at the juncture of the steel cut-off wall and the concrete corewalls built near each end of the main 340 foot embankment. Because of the one, or more stages of road widening (with apparently little control exercised regarding compaction) the buried toe drain could be acting as a lateral conduit and the seepage could be occuring practically anywhere. Due to the cut-off wall and widened base, the embankment is judged to be satisfactory regarding sliding but it is recommended that the seepage be closely observed at regular intervals. The interval between the three visits by the inspection team were insufficient to reflect any substantial change in the seepage rate. Although the asphalt paving over the main embankment is badly deteriorated, the location of the cut-off wall is clearly discernible and there is little differential settlement except for a few potholes which are the result of improper subgrade drainage rather than embankment settlement.

The general area in which the spillways are located (west of the main embankment) is of no structural concern since the two concrete spillways completely seal off the natural saddles in the outcropping bedrock. It was noted that the original length of the principal spillway (#2) was 140 feet. The crest elevation of the causeway constructed over a portion of this spillway is now roughly equal to that of the main embankment.

b. Design & Construction Data

As reviewed in Section 2, the design and construction appears to be well-engineered although the large decrease in the weir length of spillway #2 was noted. The roadway into the private

residence in front of the dam continues to serve as an auxiliary spillway in case of extreme high water. No design computations were available.

c. Operating Records

No formal records have been maintained. Judging from the overall condition and discussion with local residents, the dam has operated satisfactorily since its installation.

d. Post Construction Changes

There are no records of post-construction changes except the previously mentioned modification to spillway #2 and the widening of the main embankment for the construction of the road over the dam crest.

e. Seismic Stability

The dam is located in Seismic Risk Zone 1 and experience has established that dams in this zone will have adequate stability under dynamic loading conditions if they are stable under static loading conditions. In the opinion of the inspection team this dam is stable under static loading conditions.

SECTION 7 - ASSESSMENTS/RECOMMENDATIONS/ REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety

Subject to the physical limitations of the Phase I inspection procedures stipulated by the Corps of Engineers, the dam impounding Highland Lake is judged to be in a fair overall structural condition. The main embankment was carefully constructed to good engineering standards and is believed to be adequate to withstand a substantial amount of overtopping. No serious detrimental conditions were observed, but the seepage conditions should be further monitored to see if any corrective measures are required.

b. Adequacy of Information

No recent surveys or inspections have been made and performance data is believed to be non-existent. However, from the review of available data, it is believed that the available information is sufficiently adequate regarding the overall stability and safe operation.

c. Urgency

The remedial actions outlined below should be undertaken in the future by the owners as part of their regular maintenance program.

d. Necessity for Further Study

In accordance with Federal criteria (where spillways will not accommodate 50% of the PMF) further H&H studies are recommended but the dam is not classified as UNSAFE, NON-EMERGENCY, in accordance with ETL 1110-2-234 because failure from overtopping would not increase the hazard to loss of life downstream from a prior condition. The two natural saddles where the spillways are located would pass such a large part of any flood that overtopping of the main embankment is highly improbable.

Consequently, if the dam was ultimately overtopped, the downstream floodplain would already be completely inundated and the overtopping would not appreciably exacerbate the condition.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

a. Recommendations

1) On the basis of present conditions, structural improvement of the spillways is not feasible until further studies are completed. However, the cracks in the ogee weirs should be filled with epoxy and the expansion joints at the corners of spillway #2 wingwalls recaulked.

2) The debris and trash should be cleared from the downstream channels and the main embankment backslope.

3) The zones on the downstream slope with excessively steep grades (greater than 1:1) should be flattened with additional rock backfill.

4) The manhole entrance for the blow-off valve should be uncovered and the top casting raised and reset to roadway grade. The valve should be rehabilitated and the entrance inlet cleared of silt.

5) A V-notch weir should be installed to monitor the seepage at the toe of the dam.

b. O&M Maintenance and Procedures

Inasmuch as the dam is owned by community interests, the local police and owners should develop definitive plans for monitoring the dam during periods of heavy flows and establish a procedure for alerting the residential areas immediately downstream in the event of serious flooding conditions. The owners should develop a checklist for periodic maintenance inspections so a record of conditions and repairs can be maintained. Key personnel of their maintenance staff should be given additional training in dam safety inspection procedures so that they can correctly monitor the seepage conditions.

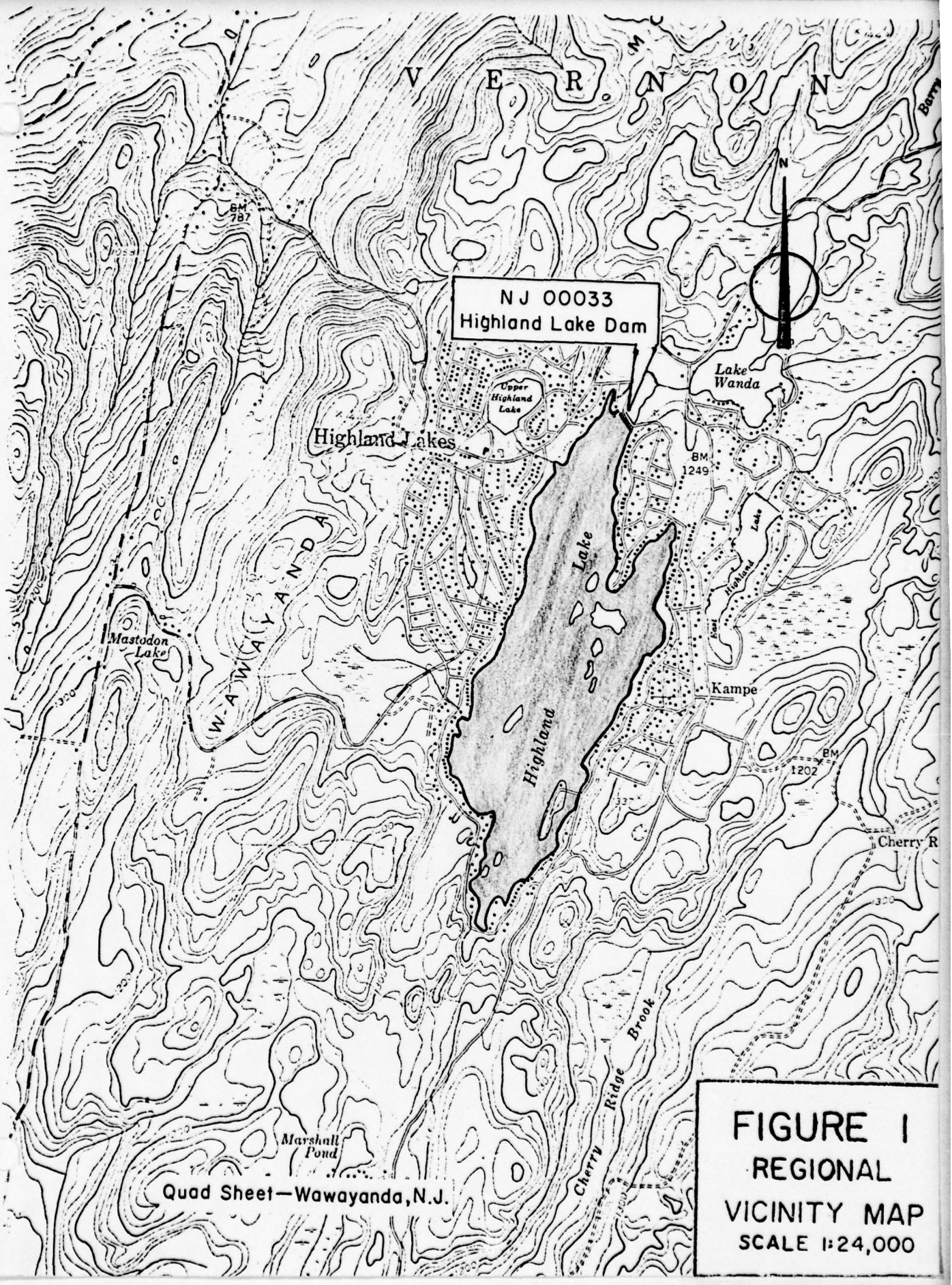


FIGURE 1
REGIONAL VICINITY MAP
SCALE 1:24,000

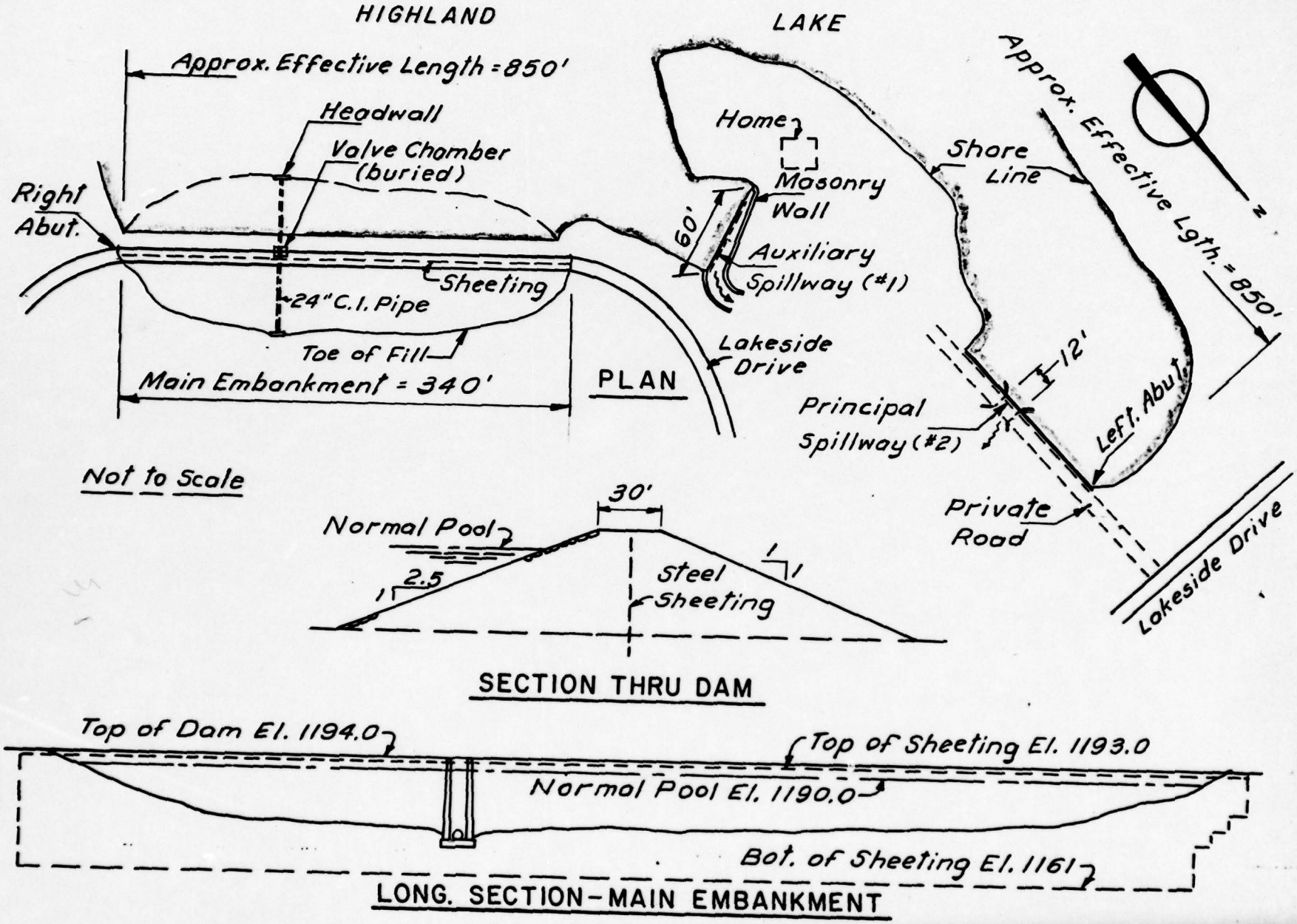

HIGHLAND
LAKE
Approx. Effective Length = 850'
Headwall
Valve Chamber (buried)
Right Abut.
Sheeting
24" C.I. Pipe
Toe of Fill
Main Embankment = 340'
PLAN
Home
Masonry Wall
60'
Auxiliary Spillway (#1)
Shore Line
Approx. Effective Lgth. = 850'
Lakeside Drive
12'
Principal Spillway (#2)
Left. Abut.
Private Road
Lakeside Drive
Not to Scale
30'
Normal Pool
2.5
1
1
Steel Sheeting
SECTION THRU DAM
Top of Dam El. 1194.0
Top of Sheeting El. 1193.0
Normal Pool El. 1190.0
Bot. of Sheeting El. 1161
LONG. SECTION - MAIN EMBANKMENT

FIGURE 2

Check List
Visual Inspection
Phase 1

Name Dam Highland Lake County Sussex State New Jersey Coordinators NJDEP

Date(s) Inspection 5/16/79 Weather Clear Temperature 65°

Pool Elevation at Time of Inspection 1190 M.S.L. Tailwater at Time of Inspection 1172 M.S.L.

Inspection Personnel:

T. Chapter K. Jolls

M. Carter D. Mulligan

K. Greenfield

T. Chapter Recorder

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None visible	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	Toe of main embankment under depth of water (could not be observed).	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Erosion along entire foreslope; cinder fill dumped on front slope which is now 1:1 down to the waters edge. Several small boat launching docks near right abutment.	
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	Dam crest is paved and has an irregular surface with humps in the road and holes in the asphalt. The crest undulates and is higher at the right abutment. Private access road at Spillway #2 in fair condition and level.	
RIPRAP FAILURES	Heavy algae growth and sedimentation obscuring riprap below the waters surface.	

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
EXCESSIVE SHRUBS, GROWTH, TREES, ETC.	Entire backslope and downstream channel covered with heavy brush and trees up to 20" in diameter.	
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Junction of embankment and left abutment is lower than rest of crest. The backslope is filled with dumped material and large boulders.	
ANY NOTICEABLE SEEPAGE	Heavy seepage at toe near right abutment. Heavy seepage 75-100 feet downstream of the right abutment and about 100 feet from the left abutment at the toe.	
STAFF GAGE AND RECORDER	None	
DRAINS	None observed	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Appears to be a 24" Ø concrete outfall pipe in a 12' long headwall. The channel is silted to within 6 inches of the pipe's top. The top of the headwall is 22" above the silt.	
INTAKE STRUCTURE	Not seen.	
OUTLET STRUCTURE	The headwall is overgrown with moss and some efflorescence was noted.	
OUTLET CHANNEL	Silted in and overgrown.	Discharges into Lake Wanda.
EMERGENCY GATE		

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	12' wide ogee weir with access road bridge 2.5 feet above crest. Appears in satisfactory condition with only light spalling and surface cracking noted.	Flow over crest about 2 inches deep.
APPROACH CHANNEL	Long, narrow finger at north end of the lake.	
DISCHARGE CHANNEL	Narrow (12' wide) channel excavated to Lakeside Dr. Heavy sedimentation in channel which has a coarse sandy-gravel bottom.	Channel passes through 2-48" dia. pipe culverts at Lakeside Dr. Below the road the channel passes a pump house 50' downstream before entering a low swampy area.
BRIDGE AND PIERS	Road is 24' wide at location of channel crossing. Light spalling inside the left conduit. Bedding is loose-fitting, unmortared masonry.	Wooden bridge across main spillway 2.5 feet above crest.

GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL		
APPROACH CHANNEL		
DISCHARGE CHANNEL		
BRIDGE AND PIERS		
GATES AND OPERATION EQUIPMENT		

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None observed	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER		

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Relatively steep and heavily wooded with heavy residential development along shore and on surrounding hills.	
SEDIMENTATION	Moderate in the vicinity of the dam.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Channel passes under Canistear Road near Wanda Lake via a corrugated arch pipe 10' wide at base, and 6' high at center. Depth of water in the pipe was 18 inches at time of inspection.	
SLOPES	Flat - swampy.	
APPROXIMATE NO. OF HOMES AND POPULATION	None unil Wanda Lake area. Fire house at road and many homes around the shoreline of the downstream lake. Restaurant located on lakeside of the road.	

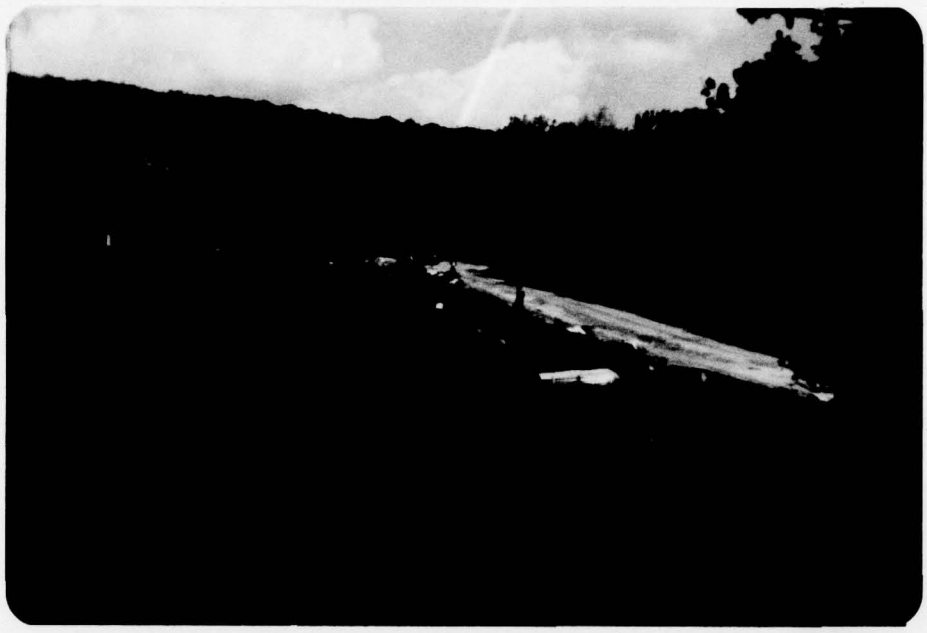
CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	Available - NJDEP - Bureau of Flood Plain Mgmt., Prospect St., Trenton, NJ
REGIONAL VICINITY MAP	Available - USGS Quad. - Wawayanda, NJ
CONSTRUCTION HISTORY	Available - NJDEP - Bur. Flood Plain Mgmt., Trenton, NJ
TYPICAL SECTIONS OF DAM	" " " " " " " "
HYDROLOGIC/HYDRAULIC DATA	" " " " " " " "
OUTLETS - PLAN	" " " " " " " "
- DETAILS	Not available
-CONSTRAINTS	" "
-DISCHARGE RATINGS	" "
RAINFALL/RESERVOIR RECORDS	

ITEM	REMARKS
SPILLWAY PLAN	Available - NJDEP - Bur. Flood Plain Mgmt.
SECTIONS	" " " " " "
DETAILS	Not available
OPERATING EQUIPMENT PLANS & DETAILS	N/A

ITEM	REMARKS
DESIGN REPORTS	Not available
GEOLOGY REPORTS	Not available
DESIGN COMPUTATIONS	Not available
HYDROLOGY & HYDRAULICS	" "
DAM STABILITY	" "
SEEPAGE STUDIES	" "
MATERIALS INVESTIGATIONS	Not available
BORING RECORDS	" "
LABORATORY	" "
FIELD	" "
POST-CONSTRUCTION SURVEYS OF DAM	Not available
BORROW SOURCES.	Not available

ITEM	REMARKS
MONITORING SYSTEMS	None
MODIFICATIONS	Available - NJDEP - Bur. Flood Plain Mgmt.
HIGH POOL RECORDS	Not available
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Not available
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE	Available - Highland Lake Assoc.
OPERATION	: " " "
RECORDS	Not available



April, 1979

View of Dam Crest

View of Drain Outlet

April, 1979

View of Primary Spillway April, 1979

View of Auxiliary Spillway April, 1979

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 2.28 sq. mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1190 MSL (1850 Acre feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N/A

ELEVATION MAXIMUM DESIGN POOL: 1190.5 MSL

ELEVATION TOP DAM: 1194 (main embankment)

CREST: Principal and auxiliary spillways

a. Elevation Principal spillway 1190; auxiliary spillway 1190.5
b. Type Reinforced concrete gravity weirs
c. Width 1.6 feet
d. Length Principal 12 feet; auxiliary = 60 feet
e. Location Spillover 450+ and 125+ feet beyond left abutment
f. Number and Type of Gates None

OUTLET WORKS: Low level blow-off pipe

a. Type 24" Ø C.I. pipe with concrete gate house and valve
b. Location 120+ feet from right abutment
c. Entrance inverts 1171+
d. Exit inverts 1170.5
e. Emergency draindown facilities Same

HYDROMETEOROLOGICAL GAGES: None
a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE: 1404 cfs

BY H.E.M. DATE 7.79 | LOUIS BERGER & ASSOCIATES INC. | SHEET NO. A1 OF ...
CHKD. BY ..... DATE ..... | HIGHLAND LAKE DAM | PROJECT .....
SUBJECT .....

Time of Concentration:

length of longest watercourse = 3000 ft. = .56 miles

$\Delta H = 1420 - 1190 = 230$ ft.

$\therefore$ Slope $= \frac{230 \times 100}{3000} = 7.6\%$

Assume velocity $= 3.5$ ft. s^{-1}

$\therefore T_c = \frac{3000}{3.5 \times 3600} = .23$ hours

By California Culvert Method:

$$T_c = \left(\frac{11.9 \times .56^3}{230}\right)^{.385} = .16 \text{ hours}$$

By Kirpichs formula:

$$T_c = 0.00013 \times \frac{3000^{0.77}}{0.076^{0.385}} = 0.16 \text{ hours}$$

7.6/100 →

take $T_c = 0.17$ hours

$$T_p = \frac{0.17 + 0.6 \times 0.17}{2} = 0.19 \text{ hours}$$

$$Q_p = \frac{484 \times 2.28}{0.19} = 5808 \text{ cfs.}$$

BY D.J.M. DATE 7-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. ____ OF ____

CHKD. BY ____ DATE ____ HIGHLAND LAKE DAM PROJECT C.234

SUBJECT ____

UNITGRAPH :

Time (hours)	T/Tp	Dimensionless Ordinate (DO)	Q (cfs) = $Q_p \times DO$
0.17	0.92	0.98	5692
0.33	1.78	0.43	2497
0.50	2.70	0.11	639
0.67	3.62	0.03	174
			Σ 9002

Check :

$$\frac{9002 \times 12 \times 3600}{2.28 \times 5280^2 \times 6} = 1.02 \approx 1 \text{ so } \underline{\text{O.K.}}$$

BY D.J.M. DATE 7-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A3 OF
CHKD. BY DATE HIGHLAND LAKE DAM PROJECT C234
SUBJECT

Precipitation Data :

from Hydrometeorological Report #33
for 200 square miles and 24 hours (in inches)

PMP = 22.5 inches

Maximum 6 hour percentage = 113 %

Maximum 12 hour percentage = 123%

Maximum 24 hour percentage = 132%

BY D.J.M. DATE 7-79 | LOUIS BERGER & ASSOCIATES INC. | SHEET NO. A4 OF
CHKD. BY DATE | HIGHLAND LAKE DAM | PROJECT C234
SUBJECT

Spillway discharge :

Over spillway as weir L = 12'

H	C	Q
0		
1	3.1	37
2	3.1	105
2.5	3.1	147

Over spillway as culvert A = 30 ft²

H	Q
3	229
4	265
5	296
6	324
7	350
8	374
9	397

Over Auxiliary spillway L = 60'

H	C	Q
0.5	3.0	64
1.5	2.9	320
2.0	2.9	492
2.5	2.9	688
3.5	2.9	1139
4.5	2.9	1661
5.5	2.9	2244
6.5	2.9	2884
7.5	2.9	3574
8.5	2.9	4312

flow over dam @ El. 1194 L = 428'

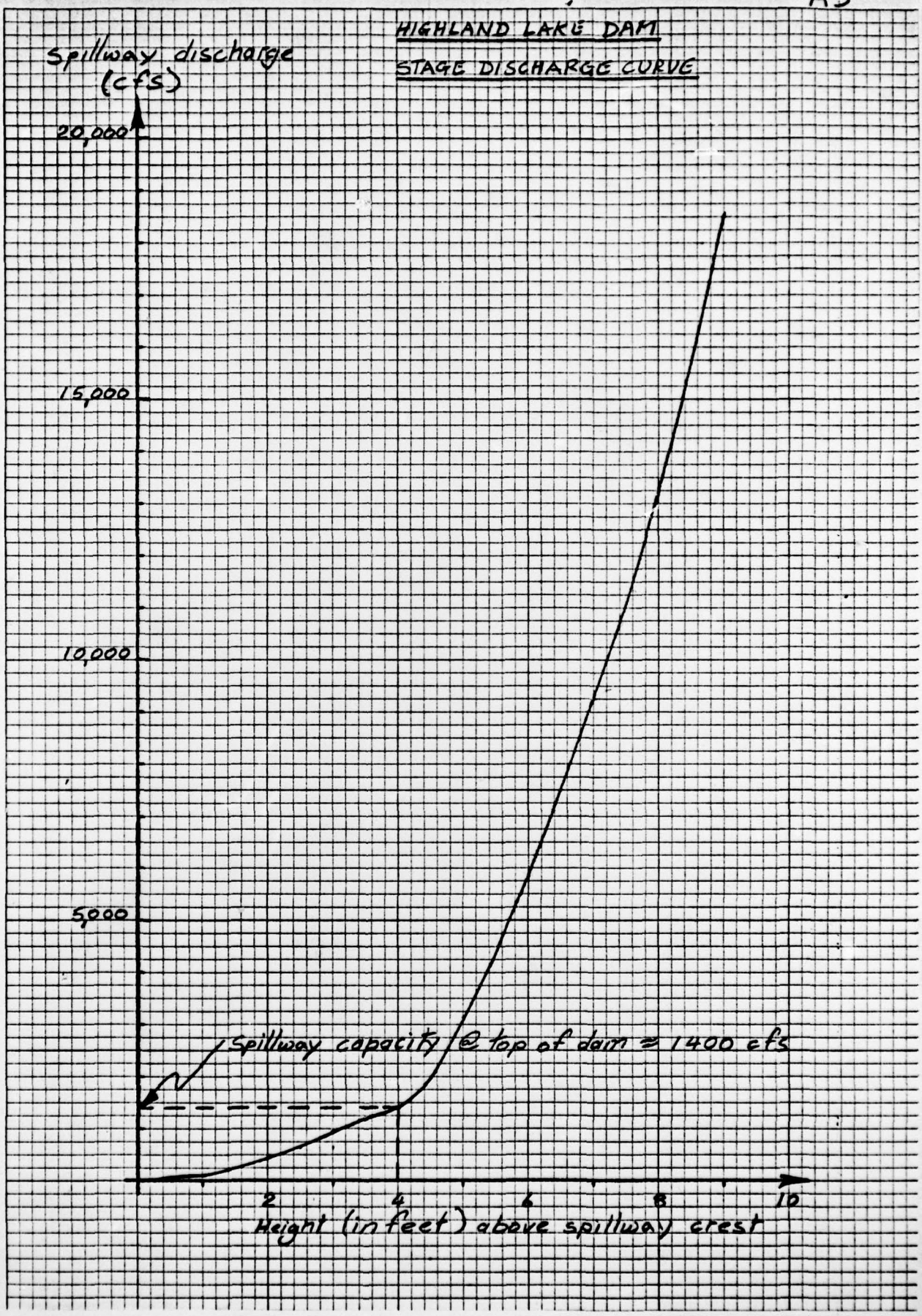
H	C	Q
1	2.7	1166
2	2.7	3269
3	2.7	6005
4	2.7	9245
5	2.7	12920

flow over dam @ El. 1198 L = 350'

H	C	Q
1	2.7	945

ΣQ

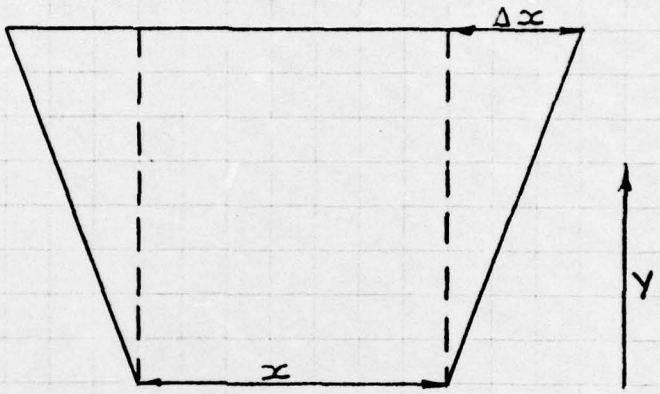
H	Q
0	
1	101
2	425
2.5	639
3	917
4	1404
5	3113
6	5837
7	9239
8	13193
9	18574



BY D.J.M DATE 7-79 **LOUIS BERGER & ASSOCIATES INC.** SHEET NO. A6 OF
CHKD. BY DATE HIGHLAND LAKE DAM PROJECT C234
SUBJECT

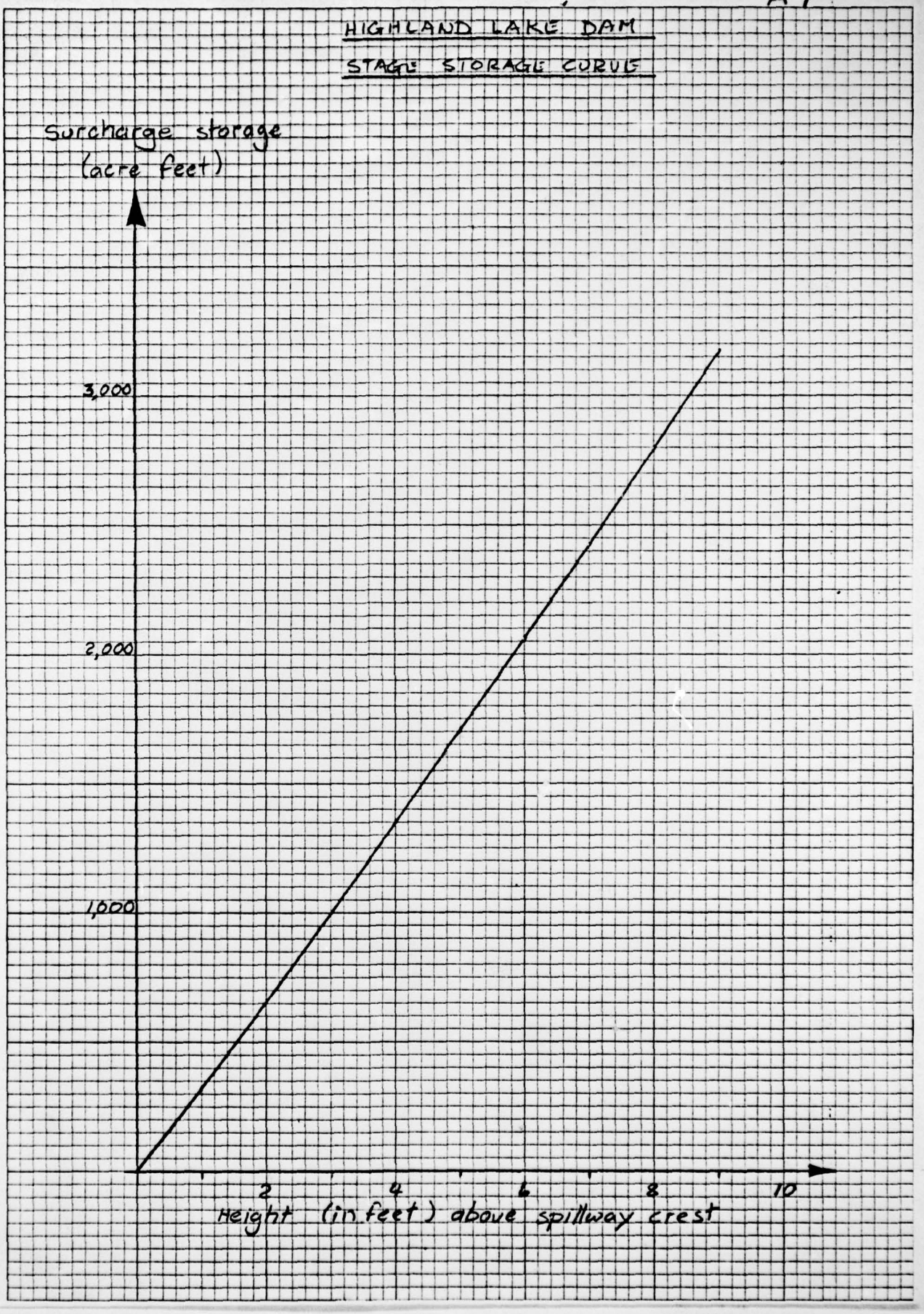
SURCHARGE STORAGE :

Area of lake @ normal pool = 325 acres
Area of lake @ top of dam = 349
Area of 1200' contour = 386 acres



Increment in volume $\Delta V = (x + \Delta x)Y$

Height in feet above spillway crest	Surcharge storage (acre feet)
0	0
1	328
2	662
3	1002
4	1349
5	1701
6	2060
7	2424
8	2795
9	3172



Available head on pipe = 18'

Storage @ normal pool = 1850 acre feet

Assume drawdown in three stages with no inflow and no tailwater

stage i) $H = 15'$
$Q \simeq 52$ cfs

$$\text{time} = \frac{1850 \times 43560}{52 \times 3 \times 3600} = 143.5 \text{ hours}$$

stage ii) $H = 9'$
$Q \simeq 40$ cfs

$$\text{time} = \frac{1850 \times 43560}{40 \times 3 \times 3600} = 186.5 \text{ hours}$$

stage iii) $H = 3'$
$Q = 23$ cfs

$$\text{time} = \frac{1850 \times 43560}{23 \times 3 \times 3600} = 324.4 \text{ hours}$$

$$\Sigma \text{ time} = (143.5 + 186.5 + 324.4)/24$$

$$= 27.27 \text{ days}$$

Say 28 days

HIGHLAND LAKE DAM
BY D.J.M.
JULY 11 1979

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
150	0	10	0	0	0	0	0	0	0

JOPER	NWT
3	0

********** ********** ********** ********** ********

SUB-AREA RUNOFF COMPUTATION

INFLOW TO RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	0	0	0	0	0	1

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	-1	2.28	0.0	2.28	0.0	0.0	0	0	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.0	22.50	113.00	123.00	132.00	0.0	0.0	0.0

TRSPC COMPUTED BY THE PROGRAM IS 0.740

LOSS DATA

STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0.0	0.0	1.00	0.0	0.0	1.00	0.50	0.10	0.0	0.0

GIVEN UNIT GRAPH, NUHGQ= 4

5692. 2497. 639. 174.

UNIT GRAPH TOTALS 9002. CFS OR 1.02 INCHES OVER THE AREA

RECESSION DATA

STRTQ= 0.0 QRCSN= 0.0 RTIOR= 1.00

END-OF-PERIOD FLOW

TIME	RAIN	EXCS	COMP Q
1	0.02	0.00	0.
2	0.02	0.00	0.
3	0.02	0.00	0.
4	0.02	0.00	0.
5	0.02	0.00	0.
6	0.02	0.00	0.
7	0.02	0.00	0.
8	0.02	0.00	0.
9	0.02	0.00	0.
10	0.02	0.00	0.
11	0.02	0.00	0.
12	0.02	0.00	0.
13	0.02	0.00	0.

14	0.02	0.00	0.
15	0.02	0.00	0.
16	0.02	0.00	0.
17	0.02	0.00	0.
18	0.02	0.00	0.
19	0.02	0.00	0.
20	0.02	0.00	0.
21	0.02	0.00	0.
22	0.02	0.00	0.
23	0.02	0.00	0.
24	0.02	0.00	0.
25	0.02	0.00	0.
26	0.02	0.00	0.
27	0.02	0.00	0.
28	0.02	0.00	0.
29	0.02	0.00	0.
30	0.02	0.00	0.
31	0.02	0.00	0.
32	0.02	0.00	0.
33	0.02	0.00	0.
34	0.02	0.00	0.
35	0.02	0.00	0.
36	0.02	0.00	0.
37	0.05	0.03	168.
38	0.05	0.03	242.
39	0.05	0.03	261.
40	0.05	0.03	266.
41	0.05	0.03	266.
42	0.05	0.03	266.
43	0.05	0.03	266.
44	0.05	0.03	266.
45	0.05	0.03	266.
46	0.05	0.03	266.
47	0.05	0.03	266.
48	0.05	0.03	266.
49	0.05	0.03	266.
50	0.05	0.03	266.
51	0.05	0.03	266.
52	0.05	0.03	266.
53	0.05	0.03	266.
54	0.05	0.03	266.
55	0.05	0.03	266.
56	0.05	0.03	266.
57	0.05	0.03	266.
58	0.05	0.03	266.
59	0.05	0.03	266.
60	0.05	0.03	266.
61	0.05	0.03	266.
62	0.05	0.03	266.
63	0.05	0.03	266.
64	0.05	0.03	266.
65	0.05	0.03	266.
66	0.05	0.03	266.
67	0.05	0.03	266.
68	0.05	0.03	266.
69	0.05	0.03	266.
70	0.05	0.03	266.
71	0.05	0.03	266.
72	0.05	0.03	266.
73	0.31	0.30	1788.
74	0.31	0.30	2456.

LOUIS BERGER & ASSOCIATES INC.

HIGHLAND LAKE DAM

75	0.31	0.30	2627.
76	0.31	0.30	2673.
77	0.31	0.30	2673.
78	0.31	0.30	2673.
79	0.38	0.36	3030.
80	0.38	0.36	3187.
81	0.38	0.36	3227.
82	0.38	0.36	3238.
83	0.38	0.36	3238.
84	0.38	0.36	3238.
85	0.47	0.45	3773.
86	0.47	0.45	4008.
87	0.47	0.45	4068.
88	0.47	0.45	4085.
89	0.47	0.45	4085.
90	0.47	0.45	4085.
91	1.19	1.18	8190.
92	1.19	1.18	9991.
93	1.19	1.18	10452.
94	1.19	1.18	10578.
95	1.19	1.18	10578.
96	1.19	1.18	10578.
97	0.44	0.42	6294.
98	0.44	0.42	4414.
99	0.44	0.42	3933.
100	0.44	0.42	3802.
101	0.44	0.42	3802.
102	0.44	0.42	3802.
103	0.34	0.33	3267.
104	0.34	0.33	3032.
105	0.34	0.33	2972.
106	0.34	0.33	2955.
107	0.34	0.33	2955.
108	0.34	0.33	2955.
109	0.02	0.01	1134.
110	0.02	0.01	335.
111	0.02	0.01	130.
112	0.02	0.01	75.
113	0.02	0.01	75.
114	0.02	0.01	75.
115	0.02	0.01	75.
116	0.02	0.01	75.
117	0.02	0.01	75.
118	0.02	0.01	75.
119	0.02	0.01	75.
120	0.02	0.01	75.
121	0.02	0.01	75.
122	0.02	0.01	75.
123	0.02	0.01	75.
124	0.02	0.01	75.
125	0.02	0.01	75.
126	0.02	0.01	75.
127	0.02	0.01	75.
128	0.02	0.01	75.
129	0.02	0.01	75.
130	0.02	0.01	75.
131	0.02	0.01	75.
132	0.02	0.01	75.
133	0.02	0.01	75.
134	0.02	0.01	75.
135	0.02	0.01	75.

136	0.02	0.01	75.
137	0.02	0.01	75.
138	0.02	0.01	75.
139	0.02	0.01	75.
140	0.02	0.01	75.
141	0.02	0.01	75.
142	0.02	0.01	75.
143	0.02	0.01	75.
144	0.02	0.01	75.
145	0.0	0.0	28.
146	0.0	0.0	7.
147	0.0	0.0	1.
148	0.0	0.0	0.
149	0.0	0.0	0.
150	0.0	0.0	0.
SUM	22.02	19.68	176261.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10578.	4519.	1224.	1175.	176261.
INCHES		18.44	19.98	19.98	19.98
AC-FT		2242.	2429.	2429.	2429.

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HYDROGRAPH ROUTING

ROUTING THROUGH RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
11	1	0	0	0	0	1

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.0	0.0	1	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.0	0.0	0.0	0.

STORAGE= 0.	328.	662.	825.	1002.	1349.	1701.	2060.	2424.	2795.
OUTFLOW= 0.	101.	425.	639.	917.	1404.	3113.	5837.	9239.	13193.

TIME	EOP STOR	AVG IN	EOP OUT
1	0.	0.	0.
2	0.	0.	0.
3	0.	0.	0.
4	0.	0.	0.
5	0.	0.	0.
6	0.	0.	0.
7	0.	0.	0.
8	0.	0.	0.
9	0.	0.	0.
10	0.	0.	0.
11	0.	0.	0.
12	0.	0.	0.
13	0.	0.	0.
14	0.	0.	0.
15	0.	0.	0.
16	0.	0.	0.
17	0.	0.	0.
18	0.	0.	0.

19	0.	0.	0.
20	0.	0.	0.
21	0.	0.	0.
22	0.	0.	0.
23	0.	0.	0.
24	0.	0.	0.
25	0.	0.	0.
26	0.	0.	0.
27	0.	0.	0.
28	0.	0.	0.
29	0.	0.	0.
30	0.	0.	0.
31	0.	0.	0.
32	0.	0.	0.
33	0.	0.	0.
34	0.	0.	0.
35	0.	0.	0.
36	0.	0.	0.
37	1.	84.	0.
38	4.	205.	1.
39	7.	252.	2.
40	11.	264.	3.
41	15.	266.	5.
42	18.	266.	6.
43	22.	266.	7.
44	25.	266.	8.
45	29.	266.	9.
46	32.	266.	10.
47	36.	266.	11.
48	40.	266.	12.
49	43.	266.	13.
50	46.	266.	14.
51	50.	266.	15.
52	53.	266.	16.
53	57.	266.	17.
54	60.	266.	19.
55	64.	266.	20.
56	67.	266.	21.
57	70.	266.	22.
58	74.	266.	23.
59	77.	266.	24.
60	80.	266.	25.
61	84.	266.	26.
62	87.	266.	27.
63	90.	266.	28.
64	94.	266.	29.
65	97.	266.	30.
66	100.	266.	31.
67	103.	266.	32.
68	107.	266.	33.
69	110.	266.	34.
70	113.	266.	35.
71	116.	266.	36.
72	119.	266.	37.
73	133.	1027.	41.
74	162.	2122.	50.
75	196.	2541.	60.
76	231.	2650.	71.
77	267.	2673.	82.
78	303.	2673.	93.
79	341.	2852.	113.

LOUIS BERGER & ASSOCIATES INC.

HIGHLAND LAKE DAM

80	382.	3108.	153.
81	423.	3207.	194.
82	465.	3232.	234.
83	506.	3238.	274.
84	547.	3238.	313.
85	590.	3505.	355.
86	639.	3891.	402.
87	688.	4038.	460.
88	738.	4076.	524.
89	786.	4085.	588.
90	834.	4085.	653.
91	909.	6137.	771.
92	1022.	9091.	945.
93	1149.	10222.	1123.
94	1277.	10515.	1303.
95	1402.	10578.	1662.
96	1521.	10578.	2239.
97	1604.	8436.	2640.
98	1640.	5354.	2816.
99	1658.	4174.	2903.
100	1671.	3868.	2966.
101	1682.	3802.	3020.
102	1692.	3802.	3071.
103	1698.	3534.	3101.
104	1699.	3149.	3104.
105	1698.	3002.	3097.
106	1696.	2964.	3088.
107	1694.	2955.	3080.
108	1693.	2955.	3072.
109	1679.	2045.	3005.
110	1649.	734.	2858.
111	1614.	233.	2688.
112	1579.	103.	2521.
113	1546.	75.	2363.
114	1516.	75.	2215.
115	1487.	75.	2076.
116	1461.	75.	1947.
117	1436.	75.	1826.
118	1413.	75.	1712.
119	1391.	75.	1606.
120	1370.	75.	1507.
121	1351.	75.	1415.
122	1333.	75.	1381.
123	1315.	75.	1356.
124	1298.	75.	1332.
125	1280.	75.	1308.
126	1264.	75.	1284.
127	1247.	75.	1261.
128	1231.	75.	1238.
129	1215.	75.	1216.
130	1200.	75.	1194.
131	1184.	75.	1173.
132	1169.	75.	1152.
133	1155.	75.	1131.
134	1140.	75.	1111.
135	1126.	75.	1091.
136	1112.	75.	1072.
137	1099.	75.	1053.
138	1085.	75.	1034.
139	1072.	75.	1015.
140	1059.	75.	997.

LOUIS BERGER & ASSOCIATES INC.

HIGHLAND LAKE DAM

	141	1047.	75.	980.
	142	1034.	75.	962.
	143	1022.	75.	945.
	144	1010.	75.	929.
	145	998.	51.	911.
	146	986.	17.	892.
	147	974.	4.	873.
	148	962.	1.	855.
	149	951.	0.	836.
	150	939.	0.	818.
	SUM			108482.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	3104.	2202.	753.	723.	108482.
INCHES		8.98	12.29	12.29	12.29
AC-FT		1093.	1495.	1495.	1495.

RUNOFF SUMMARY, AVERAGE FLOW

		PEAK	6-HOUR	24-HOUR	72-HOUR	AREA
HYDROGRAPH AT	1	10578.	4519.	1224.	1175.	2.28
ROUTED TO	11	3104.	2202.	753.	723.	2.28